

PHILIP MORRIS U. S. A.

I N T E R - O F F I C E C O R R E S P O N D E N C E

Richmond, Virginia

To: . Mr. R. S. Mullins

Date: October 18, 1988

From: . W. L. Mokarry

Subject: . Low Density Rods - Steam Residence Time Study

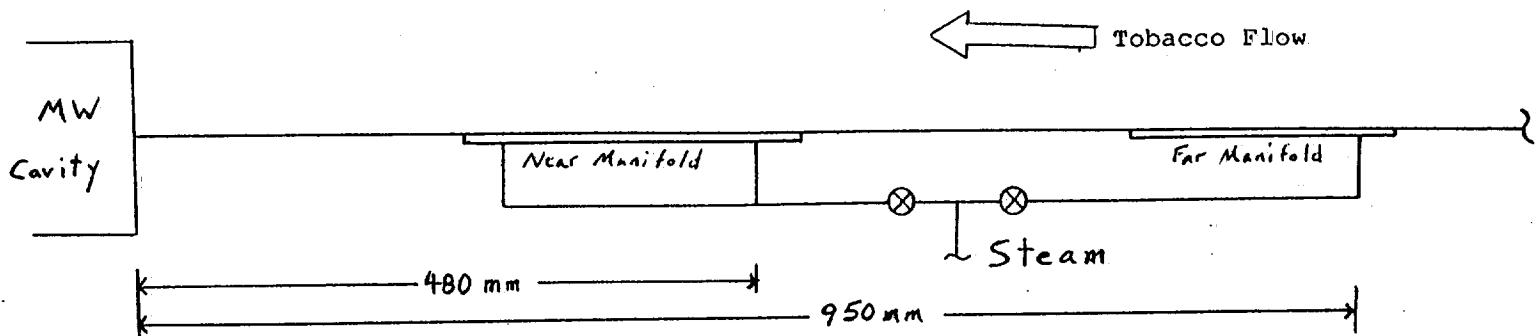
PURPOSE: To determine the effect of steam residence time on the physical quality of low density rod cigarettes. Steam residence time is defined as the length of time the filler is exposed to steam for binder reactivation before entering the microwave cavity.

CONCLUSIONS: Even at the lowest steam residence time (0.37 seconds), a good quality bonded rod was produced. For low density rods, firmness appears to be a function of tobacco weight and maker speed, but not steam residence time (over the range tested). Loose ends appear to be affected by steam residence time, as well as by cigarette weight and rod circumference. The circumference effect, however, is negative, with lower circumference values yielding greater loose ends fallout. These circumference and maker speed effects could indicate degradation of filler and/or bonds at the wrapper or tipper.

RECOMMENDATIONS: Tests should be run to study the effects of circumference variation on firmness and loose ends. A program should be initiated to determine the effect of the tipper on the quality of low density cigarettes. Also, since any relationship between maker speed and cigarette firmness would have implications for scale-up of the maker, this relationship should be further investigated.

PROCEDURE: The tobacco used in this study was blended, cased all lamina filler with a 6% add-on of a 2% undegraded Genu L200 pectin solution. Three cigarette parameters were varied during the test: tobacco weight, maker speed, and steam injection location. Two tobacco weights were run - low (575 mg) and high (650 mg). Three maker speeds were used - 650, 1000, and 1350 cpm. And two steam injection points were designed - near (480 mm from the microwave cavity) and far (950 mm from the microwave cavity).

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The above sketch shows the steam piping layout. Two valves were added to the steam piping to allow flow changes without stopping the maker. For the near location, steam is injected into a manifold via two injection ports. The further of these two points was chosen as the best representative value for the location at which the steam is present in sufficient quantities to begin binder reactivation. The far location also has steam injected into a manifold. However, only one injection port is used here. The location of the injection port is again used as the best estimate for the point at which enough steam is present to initiate binder reactivation.

The combinations of speed and distance yielded a range of residence times of 0.37 to 1.54 seconds (see Table 1). Three replications were made for each condition, and all conditions were randomized. Cigarettes were equilibrated and tested for firmness and loose ends.

RESULTS: Firmness and loose ends values are summarized in Table 1. When firmness data are plotted versus steam residence times (Figure 1), it appears that the residence time has an effect on firmness. However, if the residence time data are broken down to speed and distance parameters, a plot of firmness versus maker speed (Figure 2) yields no differences due to steam injection location. Step-wise multiple regression (equation shown in Figure 3) indicates that the factors affecting firmness are tobacco weight and maker speed¹. This is somewhat surprising, since previous analyses showed no firmness difference when maker speed was increased from 750 to 1000 cpm². However, a much larger range of speeds was examined in this study. Alternatively, the randomization of the test, with continual changes in speed over short periods of time, may have prevented the maker operating conditions from being optimized at each speed. Thus, the observed maker speed effect may be artificial.

Loose ends data, plotted in Figure 4, show a trend of increased steam residence time yielding lower tobacco fallout. When these data are plotted against maker speed with steam injection location contours (Figure 5), it is apparent that both location and speed affect loose ends results. Stepwise multiple regression (equation shown in Figure 6) indicates that steam residence time, cigarette weight, and circumference significantly affect loose ends fallout³. The overall regression is not especially good ($R^2 =$

¹ Lab Notebook 8651, pp 71 - 76.

² Douglas, S. Notebook 8709 pp 5 - 12.

³ Lab Notebook 8651, pp 77 - 82.

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0.722). One factor influencing this poor fit is the small range of loose ends values achieved.

The effect of circumference on loose ends is surprising in that the result is negatively correlated. That is, smaller circumference is seen to yield larger tobacco fallout. This is opposite of previous experience with standard cigarettes. A possible explanation for this reversal is that at the smaller circumferences, tobacco shreds or the bonds between the shreds are broken due to excess compression. Studies are planned to examine this hypothesis.

cc: Mr. H. Alonso
Mr. E. G. Craze
Mr. W. E. Claflin
Ms. S. Douglas
Mr. D. B. Knudson
Mr. A. C. Lilly
Ms. K. J. Merideth
Mr. H. B. Merritt
Mr. H. X. Nguyen
Mr. W. A. Nichols
Ms. M. E. Toerne
Mr. W. D. Winterson

Central Files

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TABLE 1

Steam Residence Times

Distance from Microwave Cavity (mm)	Marker Speed (cpm)	Residence Time (sec)
480	650	0.78
	1000	0.51
	1350	0.37
950	650	1.54
	1000	1.00
	1350	0.74

57 mm rods

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TABLE 2

Steam Residence Time Study
Firmness/Loose Ends Data

		Low Speed/Near Injection/Low Weight		
Filler Weight	mg	567	574	555
OV	%	11.90	12.12	12.43
Circumference	mm	24.89	24.80	24.80
Rod Density	g/cc	0.202	0.206	0.199
Marker Speed	cpm	650	650	650
Steam Residence Time	sec	0.78	0.78	0.78
Distance from Microwave	mm	480	480	480
Firmness	mm	3.02	2.90	2.93
Cigarette Weight	g/50 cigts	41.13	41.83	41.29
Loose Ends	g	0.15	0.16	0.16
		Low Speed/Near Injection/High Weight		
Filler Weight	mg	633	643	633
OV	%	12.19	12.32	12.24
Circumference	mm	24.86	24.82	24.97
Rod Density	g/cc	0.226	0.230	0.224
Marker Speed	cpm	650	650	650
Steam Residence Time	sec	0.78	0.78	0.78
Distance from Microwave	mm	480	480	480
Firmness	mm	2.29	2.11	2.28
Cigarette Weight	g/50 cigts	45.26	45.54	44.9
Loose Ends	g	0.14	0.10	0.10
		Medium Speed/Near Injection/Low Weight		
Filler Weight	mg	569	578	548
OV	%	12.30	12.27	12.10
Circumference	mm	24.86	24.65	24.88
Rod Density	g/cc	0.203	0.210	0.195
Marker Speed	cpm	1000	1000	1000
Steam Residence Time	sec	0.51	0.51	0.51
Distance from Microwave	mm	480	480	480
Firmness	mm	2.94	2.69	3.09
Cigarette Weight	g/50 cigts	41.51	41.78	40.55
Loose Ends	g	0.12	0.17	0.20
		Medium Speed/Near Injection/High Weight		
Filler Weight	mg	627	635	632
OV	%	12.29	12.16	12.33
Circumference	mm	24.84	24.92	24.94
Rod Density	g/cc	0.224	0.225	0.224
Marker Speed	cpm	1000	1000	1000
Steam Residence Time	sec	0.51	0.51	0.51
Distance from Microwave	mm	480	480	480
Firmness	mm	2.34	2.28	2.29
Cigarette Weight	g/50 cigts	45.04	44.96	44.63
Loose Ends	g	0.10	0.11	0.10

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Table 2
(continued)

High Speed/Near Injection/Low Weight					
Filler Weight	mg	548	574	553	
OV	%	12.23	12.27	12.14	
Circumference	mm	24.62	24.74	24.76	
Rod Density	g/cc	0.199	0.207	0.199	
Marker Speed	cpm	1350	1350	1350	
Steam Residence Time	sec	0.37	0.37	0.37	
Distance from Microwave	mm	480	480	480	
Firmness	mm	3.21	3.25	3.03	
Cigarette Weight	g/50 cigs	40.87	40.54	40.71	
Loose Ends	g	0.22	0.26	0.15	
High Speed/Near Injection/High Weight					
Filler Weight	mg	644	632	636	
OV	%	12.19	12.11	12.16	
Circumference	mm	24.90	24.60	24.86	
Rod Density	g/cc	0.229	0.230	0.227	
Marker Speed	cpm	1350	1350	1350	
Steam Residence Time	sec	0.37	0.37	0.37	
Distance from Microwave	mm	480	480	480	
Firmness	mm	2.26	2.34	2.40	
Cigarette Weight	g/50 cigs	44.41	45.16	45.06	
Loose Ends	g	0.15	0.20	0.17	
Low Speed/Far Injection/Low Weight					
Filler Weight	mg	553	538	543	
OV	%	12.19	12.14	12.32	
Circumference	mm	24.72	24.78	24.80	
Rod Density	g/cc	0.200	0.193	0.195	
Marker Speed	cpm	650	650	650	
Steam Residence Time	sec	1.54	1.54	1.54	
Distance from Microwave	mm	950	950	950	
Firmness	mm	2.87	2.99	3.01	
Cigarette Weight	g/50 cigs	40.97	40.99	40.66	
Loose Ends	g	0.08	0.08	0.09	
Low Speed/Far Injection/High Weight					
Filler Weight	mg	649	637	648	
OV	%	12.24	12.36	12.06	
Circumference	mm	24.79	24.82	24.81	
Rod Density	g/cc	0.233	0.228	0.232	
Marker Speed	cpm	650	650	650	
Steam Residence Time	sec	1.54	1.54	1.54	
Distance from Microwave	mm	950	950	950	
Firmness	mm	2.12	2.21	2.02	
Cigarette Weight	g/50 cigs	45.98	45.18	45.58	
Loose Ends	g	0.08	0.06	0.06	

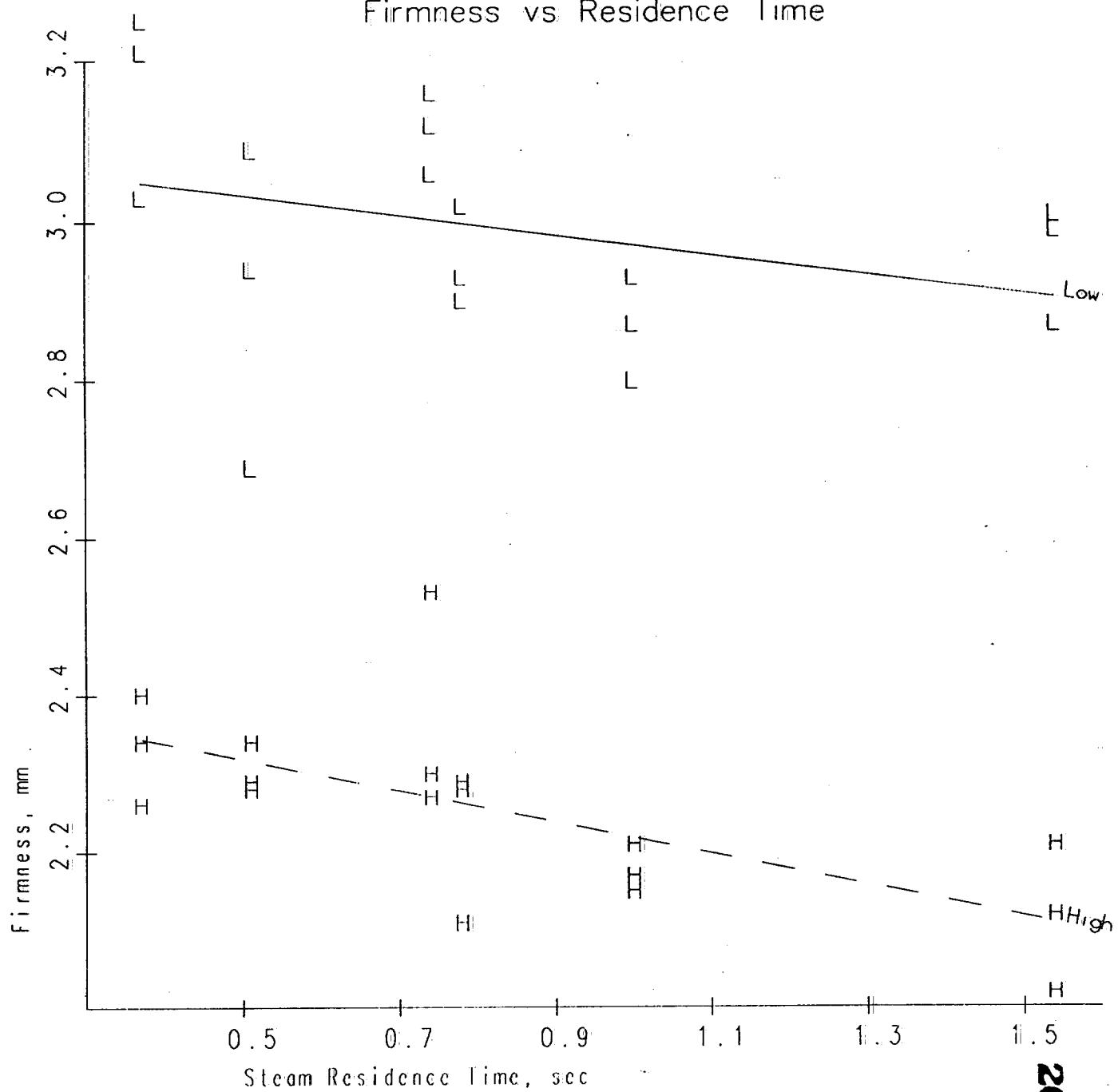
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Table 2
(continued)

Medium Speed/Far Injection/Low Weight					
Filler Weight	mg	567	563	565	
OV	%	12.18	12.15	12.09	
Circumference	mm	24.73	24.80	24.67	
Rod Density	g/cc	0.204	0.202	0.205	
Maker Speed	cpm	1000	1000	1000	
Steam Residence Time	sec	1	1	1	
Distance from Microwave	mm	950	950	950	
Firmness	mm	2.87	2.93	2.80	
Cigarette Weight	g/50 cigs	41.54	41.25	41.16	
Loose Ends	g	0.13	0.13	0.10	
Medium Speed/Far Injection/High Weight					
Filler Weight	mg	647	646	631	
OV	%	12.23	12.47	12.24	
Circumference	mm	24.80	24.51	24.85	
Rod Density	g/cc	0.232	0.237	0.225	
Maker Speed	cpm	1000	1000	1000	
Steam Residence Time	sec	1	1	1	
Distance from Microwave	mm	950	950	950	
Firmness	mm	2.17	2.15	2.21	
Cigarette Weight	g/50 cigs	45.73	45.02	45.16	
Loose Ends	g	0.12	0.10	0.08	
High Speed/Far Injection/Low Weight					
Filler Weight	mg	561	555	562	
OV	%	12.20	12.22	12.15	
Circumference	mm	24.78	24.49	24.61	
Rod Density	g/cc	0.201	0.204	0.204	
Maker Speed	cpm	1350	1350	1350	
Steam Residence Time	sec	0.74	0.74	0.74	
Distance from Microwave	mm	950	950	950	
Firmness	mm	3.12	3.16	3.06	
Cigarette Weight	g/50 cigs	41.04	41.12	40.75	
Loose Ends	g	0.18	0.21	0.16	
High Speed/Far Injection/High Weight					
Filler Weight	mg	642	633	620	
OV	%	12.29	12.14	12.25	
Circumference	mm	24.90	24.64	24.76	
Rod Density	g/cc	0.228	0.230	0.223	
Maker Speed	cpm	1350	1350	1350	
Steam Residence Time	sec	0.74	0.74	0.74	
Distance from Microwave	mm	950	950	950	
Firmness	mm	2.30	2.27	2.53	
Cigarette Weight	g/50 cigs	45.07	45.13	44.67	
Loose Ends	g	0.13	0.15	0.13	

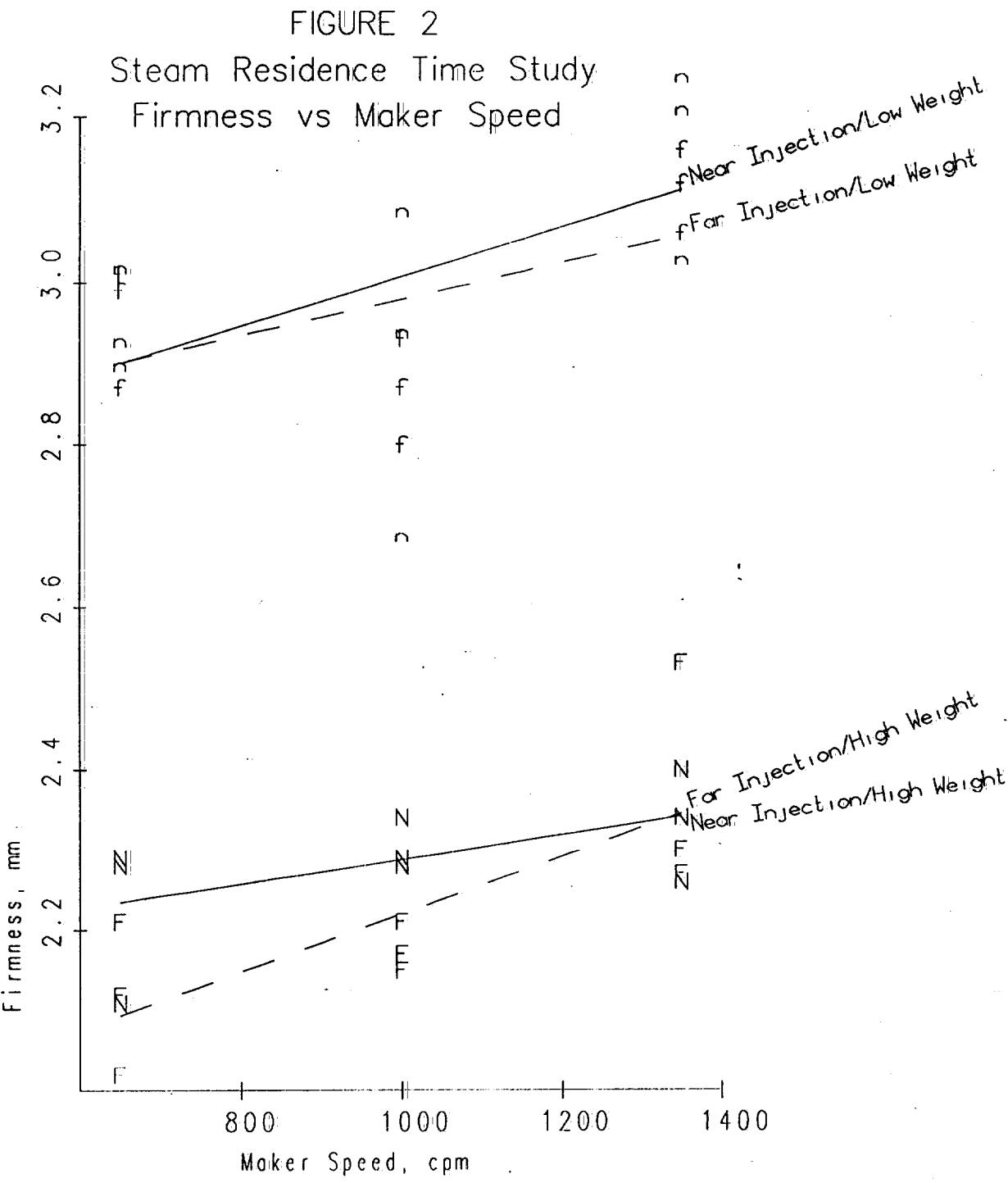
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FIGURE 1
Steam Residence Time Study
Firmness vs Residence Time



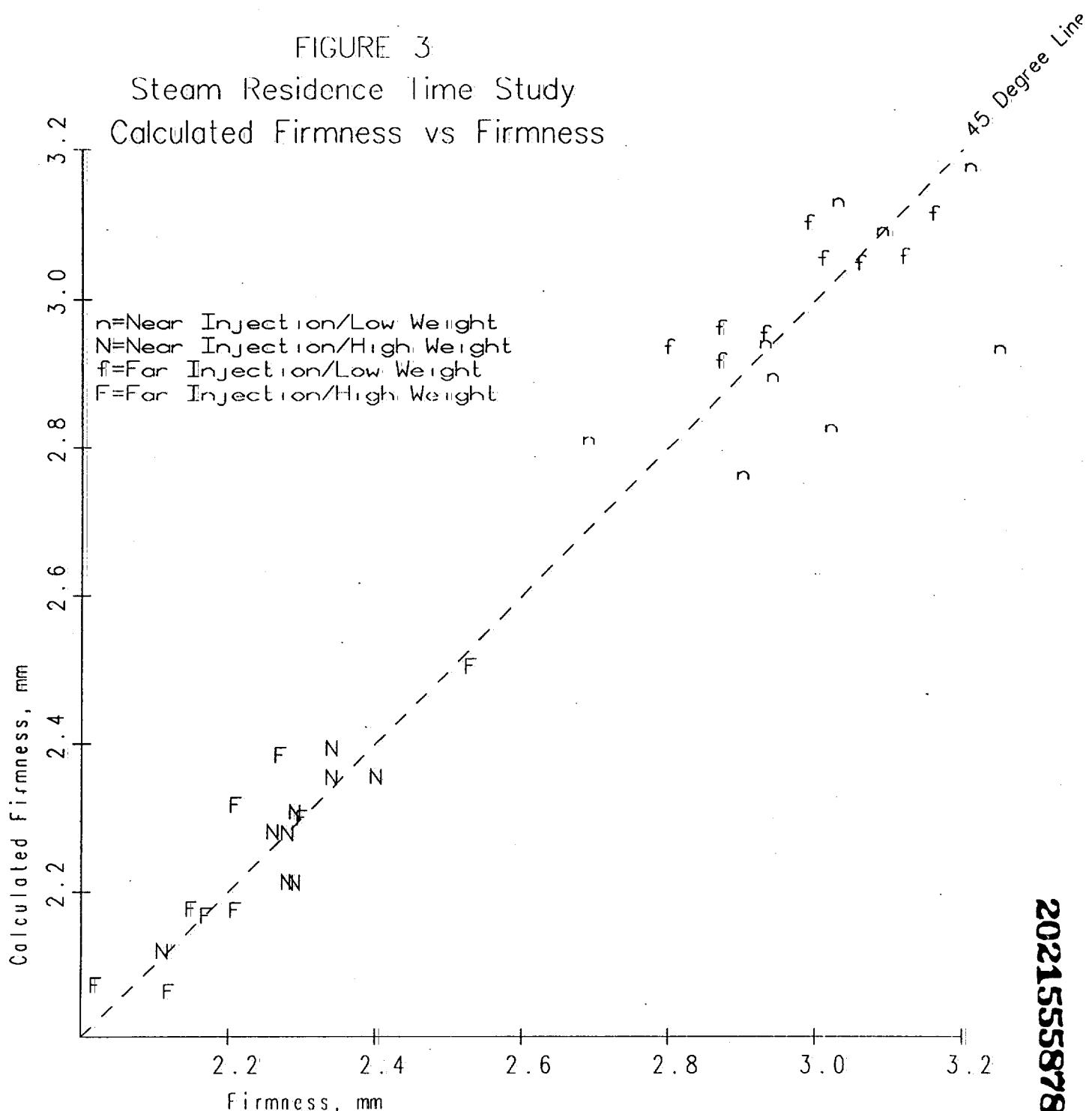
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N=Low Weight
H=High Weight

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	N	R	SD	COE0	COE1
n=Near Injection/Low Weight	9	0.5146	0.1521	2.702	0.0003018
N High Weight	9	0.581	0.06917	2.135	0.0001524
f=Far Injection/Low Weight	9	0.5574	0.108	2.755	0.0002238
F High Weight	9	0.7593	0.09918	1.863	0.0003571

FIGURE 3
Steam Residence Time Study
Calculated Firmness vs Firmness

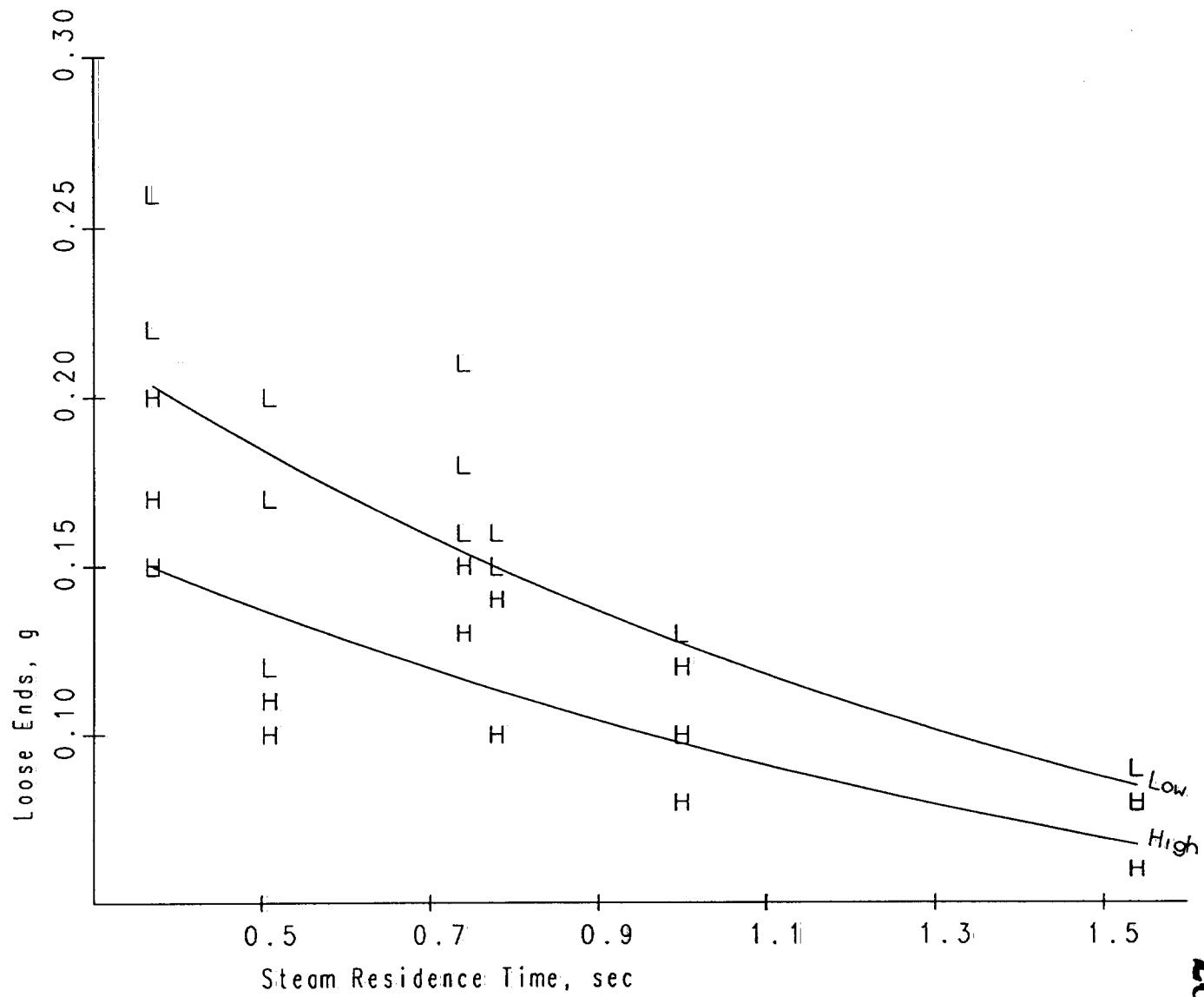


$$\text{Calculated Firmness} = 7.9809 - .0009363(\text{Tobacco Weight}) + 0.000245(\text{Marker Speed})$$

R² = 0.949 SD = 0.9219

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FIGURE 4
Steam Residence Time Study
Loose Ends vs Residence Time



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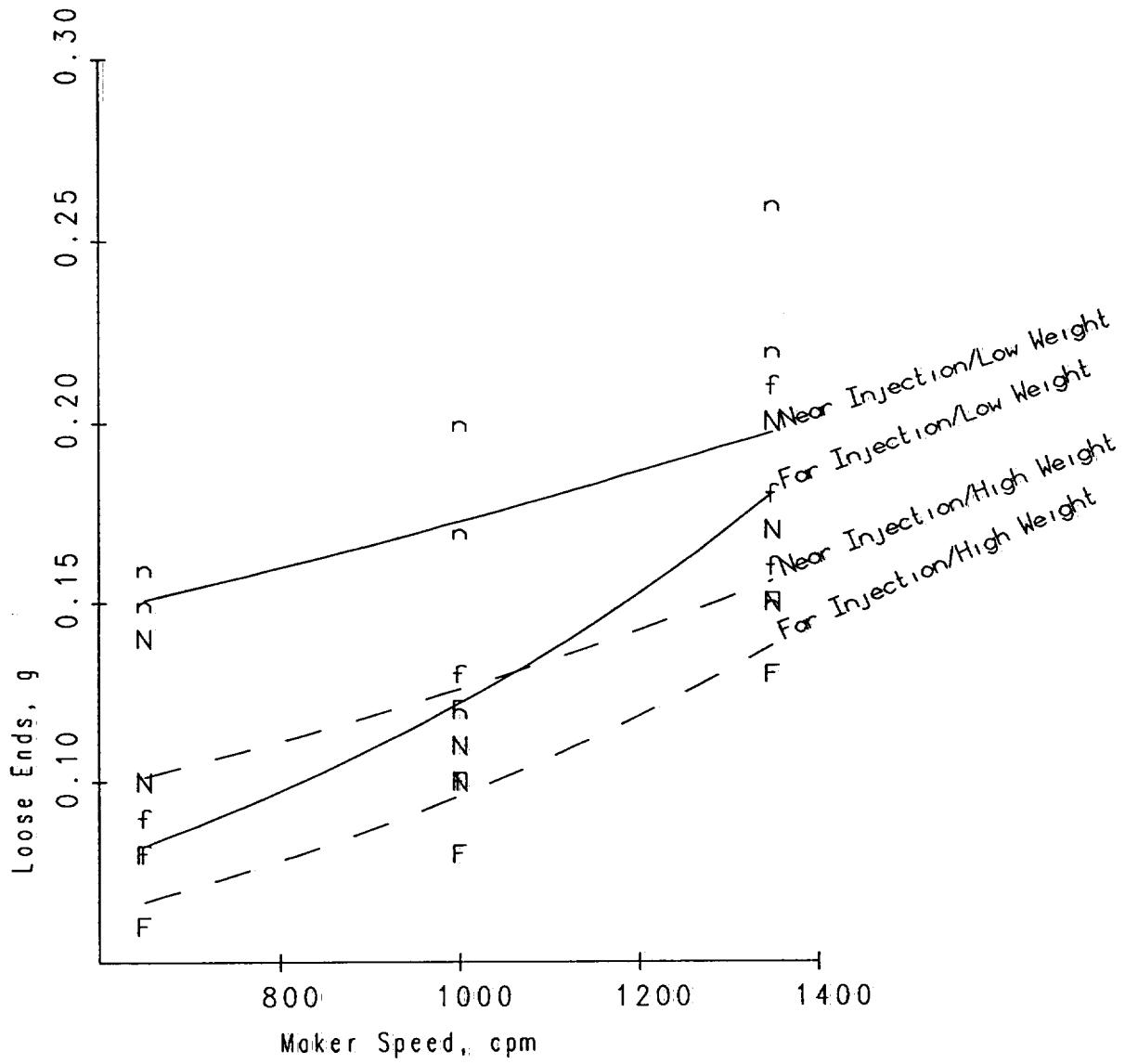
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FIGURE 5
Steam Residence Time Study
Loose Ends vs Maker Speed

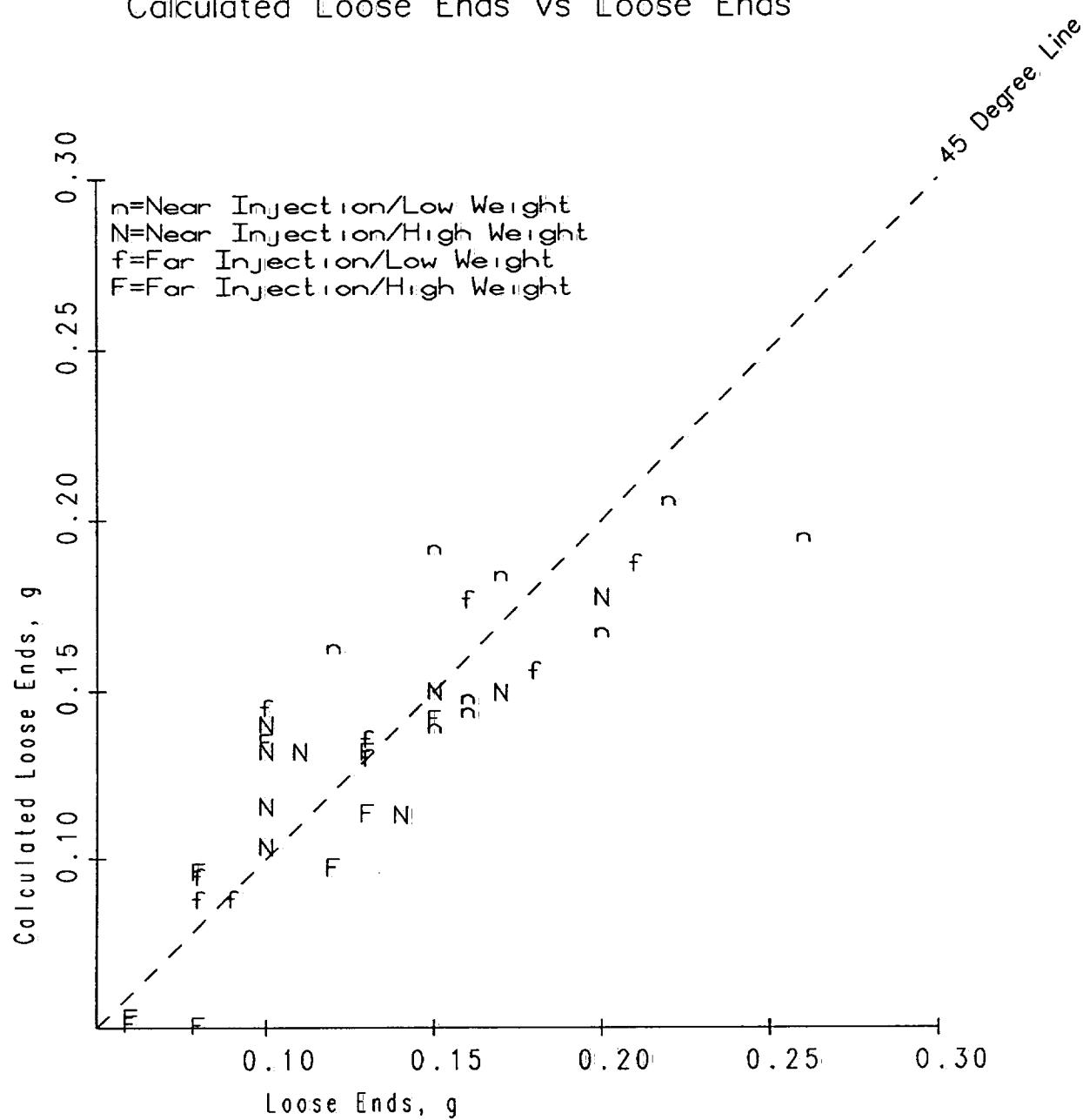


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	N	R	SD	LSD	INT	SLOPE
n=Near Injection/Low Weight	9	0.4996	0.2151	0.03603	-2.141	0.0003828
N High Weight	9	0.695	0.2064	0.0256	-2.689	0.0006156
f=Far Injection/Low Weight	9	0.9523	0.1162	0.01572	-3.225	0.00112
F High Weight	9	0.9145	0.1485	0.01315	-3.378	0.001036

$$\text{LN } Y = \text{INT} + \text{SLOPE}\#X$$

FIGURE 6
Steam Residence Time Study
Calculated Loose Ends vs Loose Ends



Calculated Loose Ends = $3.2438 - 0.08569(\text{Steam Residence Time})$
 $- 0.00728(\text{Cigarette Weight}) - 0.11(\text{Circumference})$

R² = 0.7223 SD = 0.02603

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